ENVIRONMENTAL IMPACTS OF POULTRY WASTE

Poultry raised for commercial purposes produce large amounts of manure which — unlike the manure of free range or pastured animals — is a collectible resource. It contains valuable plant nutrients and other chemicals that, if properly managed, can be returned to the land or processed for other uses. Therefore, anyone planning to undertake a confined animal feeding operation must give serious attention to the proper handling of manure and other waste products.

Factors influencing the choice of animal waste management systems begin with the type and size of the operation being contemplated, the grower's management skills and inclinations, the local environment, federal and state laws and regulations, and the effect of the proposed waste management plan on the operation's economic forecast. The importance of the choice increases in proportion to the volume and potential value of the residual materials.

For Voluntary Action

The National Farm Assessment Program (Farm*A*Syst) expanded from a 1991 pilot project in Wisconsin and Minnesota. It is funded by the USDA Cooperative State Research, Education, and Extension Service, the USDA Natural Resources Conservation Service and the U.S. Environmental Protection Agency.

A Farm*A*Syst checklist provides a simple way to identify (1) where a grower's management actions and environmental concerns intersect; (2) the degree to which current practices may be putting these vulnerable points at risk; and (3) strategic actions one can take to correct problems and reduce risk. The checklist, or self-assessment, is comprehensive but not lengthy; and it is completely private. Other Farm*A*Syst program materials explain practical management strategies and environmental regulations and how to find technical resources and financial help. Consult with local Cooperative State Research, Extension, and Education and NRCS offices for more information, access to the program, and technical support.

Concern for soil and water quality is the key to selecting a successful waste management plan, but criteria to be considered include the size of the operation, the economic consequences involved, and the growers' (and company's) personal management styles. The complexity of the system, whether it is dry or liquid, and the best management practices that can be used to minimize its effects on the environment are the subject of subsequent fact sheets in this series.

Begin with the Land/Water Interface

Whether the wastes or by-products that accompany poultry growouts are good or bad for the environment depends in large part on interactions between the activities of the producers and the ecosystem. Hence, planning efforts begin with an assessment of the farmstead's location in relation to rivers, lakes, ponds, ditches and sinkholes; the chemical and physical properties of the soil profile; the availability of agricultural land in the production area; and the possible effects of poultry production on the naturally occurring cycles of nitrogen and phosphorus.

Why Begin with Water

Agricultural activities, including — in some areas — mishandled or excessive poultry wastes, are a major source of nonpoint source pollution, although agriculture and forestry management are not the only sources. Crop production, pastures, rangeland, feedlots and other animal holding areas are agricultural sources of the U.S. waters assessed, 50 to 60 percent of the water quality problems in rivers and lakes and 34 percent of the waters in more urbanized coastal areas are impaired from agricultural sources. Bacteria, sedimentation, and nutrients are the leading pollutants.

Properly managing manure, controlling runoff, and nutrient management planning in conjunction with land applications will reduce or eliminate much of the proposed source of pollution and contribute to more productive farming. Most nonpoint source pollution problems can be controlled if growers know how nutrients and soil interact and plan accordingly.

Nitrogen, phosphorus, and potassium move through cycles on a farm. As nutrients, they go from crops to animals (in feed) to the soil (waste applications) and back again to other crops. If the cycle holds, everything works as it should. But too many nutrients already in the soil or too much waste applied to the land can move with the soil into surface water or through the soil into groundwater until their presence in the water reaches unacceptable levels, that is, is sufficient to impair water quality.

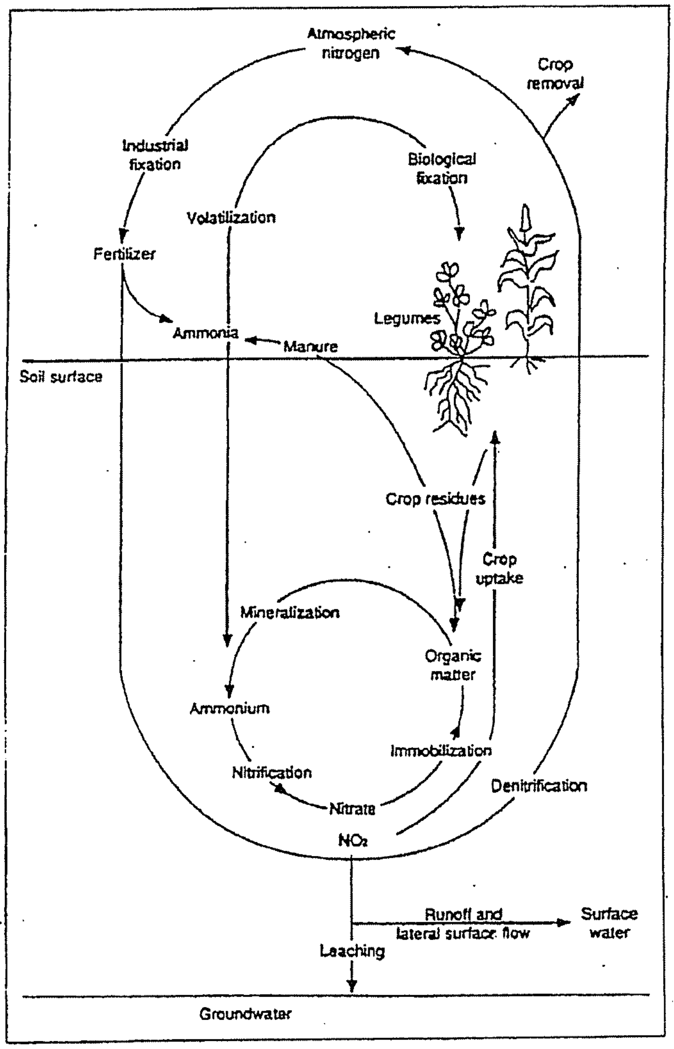

Figure 1.—The nitrogen cycle. Source: Pennsylvania State University, College of Agriculture. 1989. Groundwater and Agriculture in Pennsylvania. Circular 341. Reprinted with permission.

Nitrogen

Of the three major nutrients in poultry waste, nitrogen is the most complex and hence the most likely to contribute to environmental problems. Most of earth's nitrogen exists as nitrogen gas in the atmosphere (see Fig. 1). It can be transformed into inorganic forms by lightning or into organic forms by plants, such as soybeans, alfalfa, or clovers. Nitrogen can also be transformed into inorganic forms (commercial fertilizers) by energy intensive processes.

Most of the nitrogen found in animal wastes is organic nitrogen. A smaller amount of the nitrogen in litter is ammonium. Organic nitrogen can be mineralized or converted by soil bacteria into inorganic nitrogen, the form in which nitrogen is available to plants. Excessive organic and ammonium forms of nitrogen will be transformed in soil into nitrate nitrogen (that is, into water soluble nitrogen).

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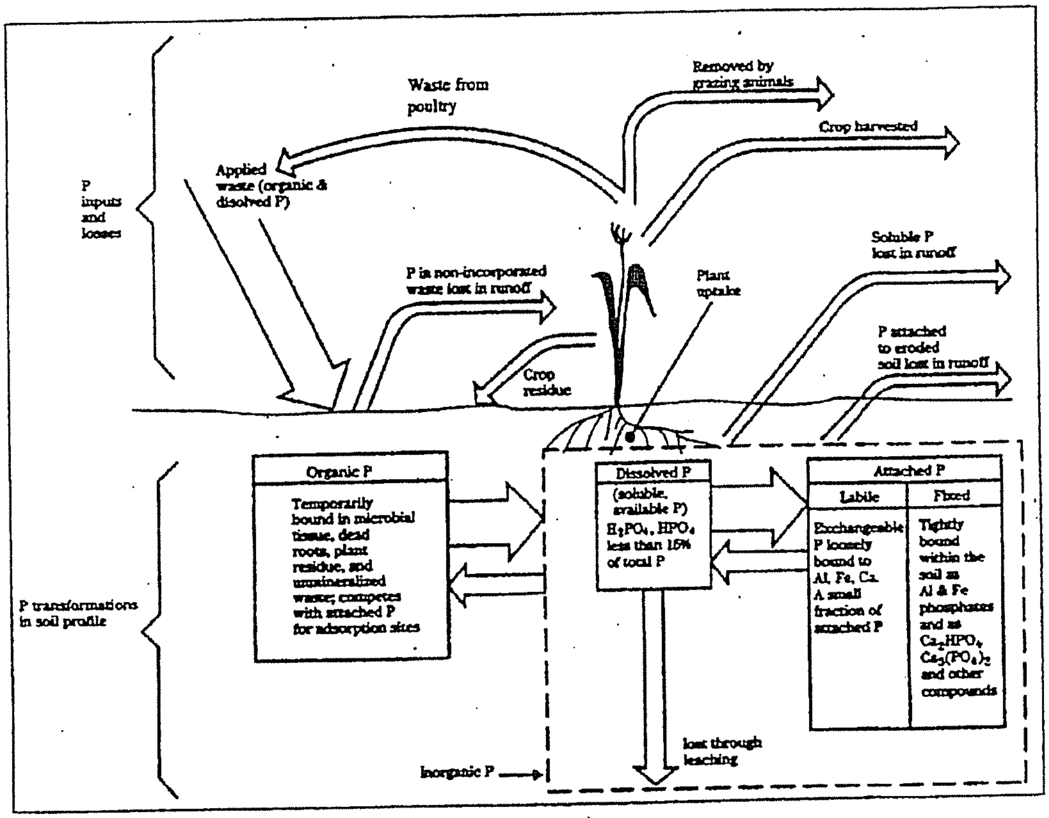

Figure 2.—Abbreviated phosphorus cycle.

Losses of nitrogen regardless of source (e.g., manure, commercial fertilizer, or municipal biosolids) from the cropping system can occur as a result of volatilization, surface runoff, and leaching. Surface runoff can move dissolved nitrogen (especially nitrate), ammonium nitrogen attached to eroding soil particles, and organic nitrogen contained in organic or plant residues into streams and lakes. Nitrates also move with the soil or leach through well-drained soils past the root zone into the groundwater supply.

High levels of nitrate can be toxic to human health, especially newborns. Nitrates reduce the blood's capacity to carry oxygen or cause internal suffocation. Scientists tell us that too much nitrate can affect the weight, feed conversion, and performance of poultry. Too much nitrogen in surface water makes the water less productive and may result in fish kills.

Phosphorus

Poultry wastes also contain significant amounts of phosphorus (see Fig. 2). Phosphorus, like nitrogen, is essential for plant and animal growth and also contributes to environmental problems. In fact, it seems to be the limiting factor in the huge algae blooms that make lakes unfit for swimming and ultimately deplete their oxygen supply, deadening the water and killing fish. Phosphorus has become a major cause of water quality degradation.

Phosphorus exists in either dissolved or solid form. Dissolved phosphorus usually exists as orthophosphates, inorganic polyphosphates, and organic phosphorus in the soil. Phosphorus in the solid form is referred to as particulate phosphorus and may be composed of many chemical forms. Particulate phosphorus comes in four classifications:

- adsorbed phosphorus, which attaches to soil particles;

- organic phosphorus, which is found in dead and living materials;
- precipitate phosphorus, which is mainly fertilizer that has reacted with calcium, aluminum, and iron in the soil; and
- mineral phosphorus, the phosphorus in various soil minerals.

Approximately two-thirds of the total phosphorus in soil is inorganic phosphorus; the remaining one-third is organic. Both forms are involved in transformations that release water-soluble phosphorus (which can be used by plants) from solid forms, and vice versa.

Phosphorus-laden soil or dissolved phosphorus can move via runoff into rivers, lakes, and streams, where it causes excessive plant and algae growth, which in turn depletes the dissolved oxygen content in the water. Phosphorus-enriched waters contribute to fish kills and the premature aging of the waterbody. In the end, the beauty and use of the waters are seriously curtailed. Even relatively small soil losses may result in significant nutrient depositions in the water.

Controlling soil erosion and proper land application of phosphorus-containing wastes will greatly reduce the amount of phosphorus in water. While not normally a great concern, care must also be taken to prevent soluble phosphorus from leaching into groundwater.

Applying poultry waste to land at rates based on supplying the nitrogen needs of grain or cereal crops can lead to a phosphorus buildup in the soil. Planting forage crops in rotation with grain crops will help remove excess phosphorus. Maintaining soil pH at the recommended level is also an effective and economical practice for maximizing phosphorus efficiency. Crops use phosphorus most efficiently when the soil pH is between 6.0 and 7.0.

Soil phosphate levels are an important consideration in calculating poultry litter application rates. Land applications should be made only to soils that do not already contain excessive phosphate levels. An analysis or test should be conducted on each waste source prior to land application to determine proper phosphorus application rates.

Potassium

Potassium in poultry waste is a soluble nutrient equivalent to fertilizer potassium. It is immediately available to plants when it is applied. Potassium is fairly mobile but does remain in the soil to help supply plant needs, for example, strong stems, resistance to disease, and the formation and transfer of starches, sugars, and oils. Excessive amounts of potassium can inhibit or restrict the growth of some plants at certain stages of development. Small amounts of potassium may be leached to groundwater, especially in sandy soils; however, potassium or potash is usually not a threat to water quality or considered a pollutant.

Heavy Metals and Trace Elements

Heavy metals and trace elements, such as copper, selenium, nickel, lead, and zinc, are strongly adsorbed to clay soils or complexed (chelated) with soil organic matter, which reduces their potential for contaminating groundwater. However, excessive applications of organic waste containing high amounts of heavy metals or trace elements can exceed the adsorptive capacity of the soil and increase the potential for groundwater contamination. Excessive application of some heavy metals, for example, copper can be toxic to plants whose growth is needed to take up other nutrients.

Surface water contamination is a potential hazard if poultry wastes are applied to areas subject to a high rate of runoff or erosion.

Salts

Dissolved salts, mainly sodium, in high concentrations interfere with plant growth and seed germination, and may limit the choice of plant species that can be successfully grown. Poultry waste with low salt content and a high carbon to nitrogen ratio can improve soil water intake, permeability, and structure.

Using Litter Nutrients Wisely

High nitrate levels in groundwater and high phosphorus levels in surface water may be an indication that too much litter or fertilizer is being applied on too little land. Yet the fact that poultry litter is high in nutrients is precisely its value. The nutrients in this resource make it an excellent soil conditioner and fertilizer. Growers can maximize the benefits of having this re-

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source and help protect their local water resources from high nutrient levels by planning and operating an effective nutrient management system.

Application practices will vary with the area's cropping practices, topography, and other environmental and economic conditions. Waste and soil testing are the simplest and most important aspects of nutrient management. They help farmers monitor the nutrient supply to guarantee that it is adequately controlled to produce the best crop yields and maintain water quality. When properly recycled, nutrients are not wastes but opportunities to improve the overall farming operation.

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Other pages in this handbook contain more detailed information on these subjects. The Poultry Water Quality Consortium is a cooperative effort of industry and government to identify and adopt prudent uses of poultry by-products that will preserve the quality of water for everyone.

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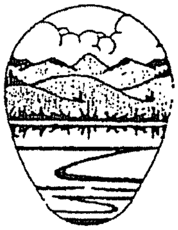

Planning Poultry Waste Management

Poultry litter is a valuable by-product of the poultry industry. It is, for example, a natural soil amendment — a source of nutrients and organic matter that can increase soil tilth and fertility. If it is mishandled, it is also a potential pollutant of surface and groundwater.

Developments within the poultry industry and increasing restrictions or regulations on the disposal of poultry waste have significantly altered the industry's attitudes about this immense resource. Broiler operations alone produced over 15.2 billion pounds of litter in 1996, and because production is concentrated in very small geographic areas, waste management planning is extremely important.

Historically, poultry growers applied poultry waste to their farms as much to dispose of the material as to use it for fertilizer. Difficulties with this practice increase with the supply for several reasons:

- Less cropland is farmed than 20 years ago, and more poultry operations exist than in the past.
- Typically, more nutrients are brought onto the farm in the form of feed than leaves the farm in the form of meat or eggs. The nutrients left on the farm are in the manure and bird mortalities.
- Other resources (wastewater, composted residential waste, and sludge) are also being used for land applications, which increases competition for the remaining croplands and pastures.
- We know now that valuable nutrients — nitrogen, phosphorus, and potassium — are squandered and water resources are threatened if land applications of waste are overdone or misapplied.
- Regulations regarding waste management are now enforced by many states.

Increasingly, concern for water quality has become a major catalyst for the upsurge of interest in new approaches to land application. Today's growers are finding that they can no longer afford to dismiss the benefits of poultry waste planning, which include increases in farm production, environmental protection, and lower costs.

Plan Components

The waste management system must provide for the collection, storage, and final distribution (use) of manure and dead birds in an environmentally safe way. State laws generally do not permit direct discharges of animal waste into water, and many states require permits for confined animal operations beyond a certain size. Soil and water quality considerations are the key to choosing among types of waste management systems (for example, whether to install a dry or liquid system).

Components will depend on the operation's size, operating plan, and the producer's access to technical expertise. For example, one facility may have an incinerator for handling dead birds; another may have an incinerator and a composting facility.

Components of waste management systems include, but are not limited to, the following:

- composting facilities;
- debris basins;
- dikes, diversions, and fencing;
- filter strips and grassed waterways;
- transportation and other heavy use area protections and equipment;

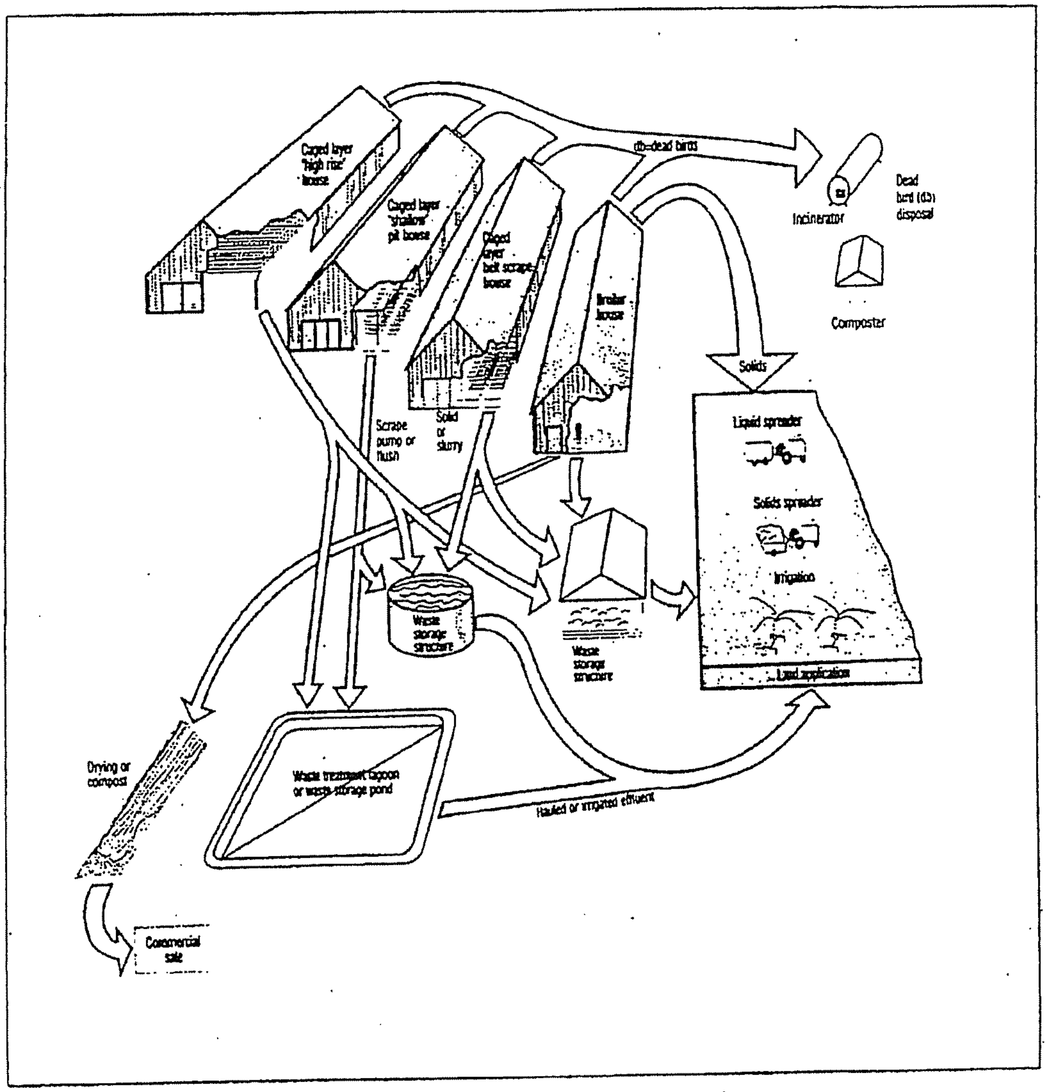

Figure 1.—Representative components of a poultry waste management system.

- irrigation schedules and equipment;
- nutrient management planning, including soil and manure testing procedures;
- pond sealings or linings;
- subsurface or surface drains, or both; and
- waste storage ponds, other storage structures, and treatment lagoons.

The relationship among these components is shown in Figure 1. Note that the drawing contains a broiler house and several examples of caged layer houses. Figure 2 shows the six stages of animal waste management.

An Integrated Approach

Traditionally, poultry growers have efficiently disposed of litter as soon as possible by spreading the manure or litter on croplands or pasture. Now growers must begin their waste

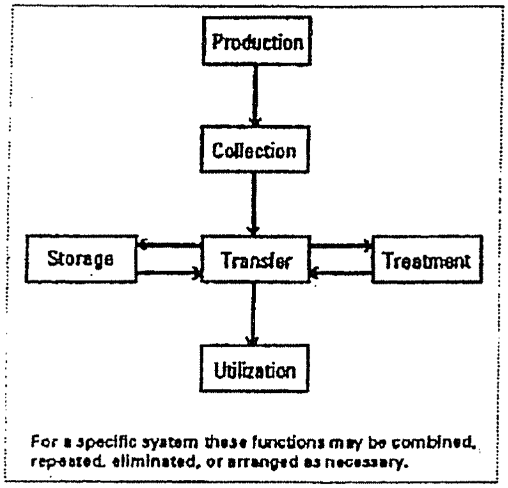

Figure 2—Steps in an animal waste management planning system.

management inside the poultry house. Along with the objectives of flock health, production, and odor control, today's waste management planning must also protect water quality and contribute to a profitable farm operation. Integrating these broad objectives requires growers to develop other options in addition to land application.

Thus, to be profitable and to protect our natural resources — air, soil, water, plants, and animals — poultry growers must plan their waste management practices carefully. They must base application rates and timing on soil test results and crop removal needs along with an analysis or estimate of the nutrients contained in the manure or litter.

Poultry waste management planning begins before actual production and may have as many as six steps or functions (Fig. 2). The first step is to understand the waste management process. What are these wastes? How much does a particular operation produce on an annual basis? Where or how can these wastes be used? The second step, once the quantity and quality of the wastes have been determined, is to put efficient collection methods in place.

The third and fourth steps are to have adequate storage facilities and the ability to transfer or move the waste from the point of collection to the appropriate point of use. In some cases, a fifth step is included to determine whether biological, physical, or chemical treatment of the wastes is needed to reduce the potential for pollution or to prepare the wastes for final use.

The sixth and final step in the waste management plan is to use the wastes — normally, for land application as a fertilizer and soil improvement or as a feed ingredient — in accordance with the nutrient management plan. Growers will usually have identified sufficient land on which to apply the waste before production begins. If enough land does not exist, other uses must be assigned or additional lands located for disposal.

The Benefits of Nutrient Management

Nutrient management actually begins when the poultry waste process has proceeded from collection and conservation to the actual use of these products for land applications or energy and feed production. Nutrient management planning matches the nutritional requirements of the soils, crops, or other living things with the nutrients available in the manure or litter, thereby preventing nutrient imbalances, health risks, and surface and groundwater contamination.

Nutrient value is based on the nitrogen, phosphorus, and potassium content of poultry waste. This value can be enhanced by matching the nutrients available in the resource with the nutrients needed in the application. This planning also reduces disposal and handling costs. Nutrient management planning makes it possible to use poultry manure to replace commercial fertilizers or at least to reduce their use — thereby reducing some costs of crop production. Nutrient management also minimizes the potential harmful effects that overapplication can have on the environment.

An essential goal of nutrient management is to make sure that any poultry waste, especially manure or litter, is used safely and effectively. Nutrient management is, in fact, the key to using this waste as a beneficial by-product. To obtain maximum benefit and prevent possible contamination of surface and groundwater, the following management principles and practices can be applied:

- Develop and apply a Resource Management System, an Animal Waste Manage-

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ment System, a Nutrient Management Plan, or similar program. Assistance is available from the local offices of the U.S. Department of Agriculture's Natural Resources Conservation Service, the Cooperative State Research, Extension, and Education Service, state departments of agriculture, or soil and water conservation districts.

- Find out if your state uses nitrogen as a basis for land application requirements. If not, is phosphorus a concern in your area?
- Analyze poultry waste regularly to monitor major nutrients and pH levels. Proper soil pH will help maximize crop yields, increase nutrient use, and promote decomposition of organic matter.
- Apply only as much fertilizer (nutrients) as the crop can use.
- Calibrate equipment and apply waste uniformly.
- Incorporate poultry waste into the soil if possible to reduce runoff, volatilization, and odor problems.
- Do not spread poultry waste on soils that are frozen or subject to flooding, erosion, or rapid runoff prior to crop use.
- Spread poultry waste during specific growing seasons or as scheduled for maximum plant uptake and to minimize runoff and leaching.
- Use proper storage methods prior to land application.
- Maintain a vegetative buffer zone between the field of application and adjacent streams, ponds, lakes, sinkholes, and wells.
- Follow approved conservation practices in all fields.
- Be considerate of neighbors and minimize conflicts when transporting or land applying poultry waste.

Training, technical assistance, and in some cases, financial aid are available to help growers and crop farmers identify problems and develop solutions for using poultry waste in their specific regions. The Natural Resources Conservation Service and Cooperative Extension Service have developed work sheets for animal waste management systems that help growers estimate production, obtain soil and manure analyses, and make economical and practical use of the organic resources generated on the farm. These agencies and others can help growers design facilities and develop overall resource management plans.

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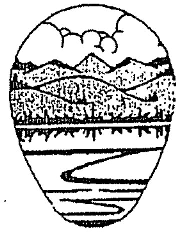


DRY WASTE MANAGEMENT

A well-planned waste management system will account for all wastes associated with a poultry agricultural enterprise throughout the year, from the production of such wastes to their ultimate use. The more integrated the waste management system is with the grower's other management needs, such as production, marketing, pest control, and conservation, the more profitable the farm will be.

The best method for managing poultry manure depends on the type of growing system (open range or enclosed housing), dry or liquid collection, and the way the house is operated. Misuse of poultry manure can reduce productivity; cause flies, odor, and aesthetic problems; and pollute surface and groundwater. Poultry manure can produce dust and release harmful gases such as carbon dioxide, hydrogen sulfide, methane, and ammonia. Fresh manure is troublesome if it gets too wet.

Poultry wastes are handled differently depending on their consistency, which may be liquid, slurry, semisolid, or solid. The total solids concentration of manure depends on the climate, weather, amount of water consumed by the birds, type of birds produced, and their feed; it can be increased by adding litter or decreased by adding water.

Within the poultry industry, broiler, roaster, Cornish hen, pullets, turkey, and some layer operations are dry; live bird processing, some layer, and most duck and goose operations are liquid. In most dry operations, the birds are grown on floors covered with bedding materials. The manure collected from ducks, geese, and large high-rise layer operations is usually pure or raw manure, unmixed with litter though it may be mixed with water during cleanout.

Open Range or Enclosed Housing

Fields, pastures, yards, or other outdoor areas are used as ranges for chickens, turkeys, ducks, or game birds. Such areas must be located and fenced so that manure-laden runoff does not enter surface water, sinkholes, or wells. Unless these areas are actually feed lots (confinement areas that do not support vegetation), no collection and storage of manure is required. Instead, the manure is recycled directly to the land. Best management practices, such as pasturing the animals away from sinkholes and other water resources, and preventing animal access to streams, apply to these operations. In confinement operations, by contrast, the manure is collectible and can become a valuable coproduct of the operation.

In enclosed settings, dry and liquid wastes require different collection, storage, handling, and management systems. The management of dry manure depends primarily on how it is stockpiled or stored from the time of its production (at cleanout) until it is properly land applied. The following paragraphs describe general house conditions that affect the production and quality of this material and the principles of dry waste management. Liquid waste management is explained in an additional fact sheet contained in this handbook (PWM-4).

Kinds of Poultry Waste — Manure and Litter

Livestock manure is feces and urine; poultry waste is manure with added bedding or water. The only way to know for certain its quantity, concentration and composition is from lab analysis. The amount of manure a given flock produces can be estimated from the amount of feed the birds eat. Roughly 20 percent of the feed consumed by poultry is converted to manure. Manure mixed with a

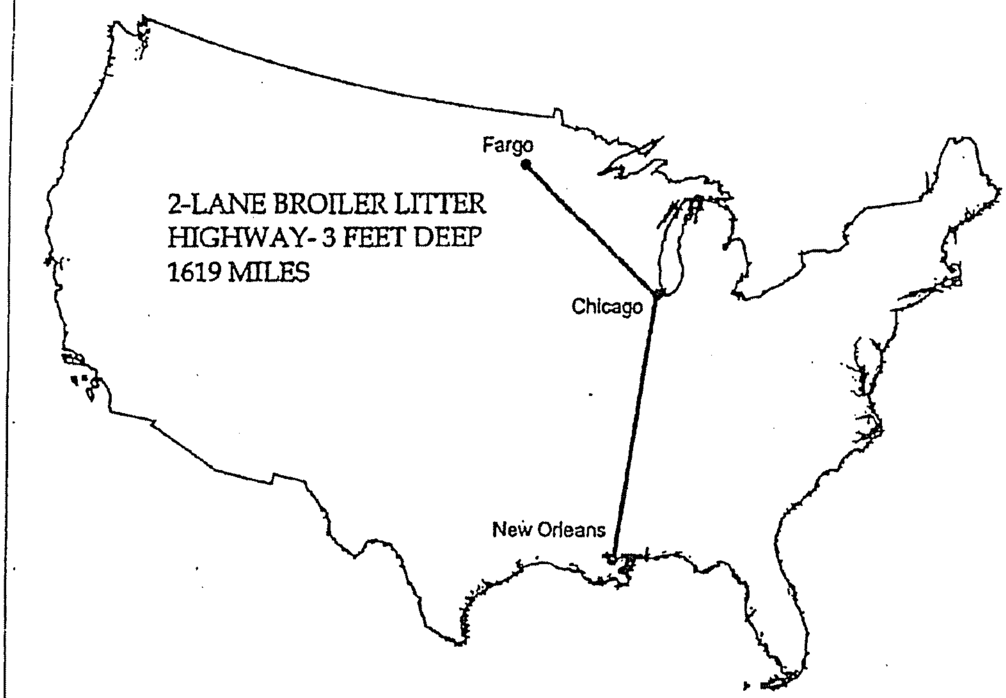


Figure 1.—The broiler litter highway: broiler litter generated in 1996, in the United States.

water. The only way to know for certain its quantity, concentration and composition is from lab analysis. The amount of manure a given flock produces can be estimated from the amount of feed the birds eat. Roughly 20 percent of the feed consumed by poultry is converted to manure. Manure mixed with a bedding material is called litter, and its constituent properties vary, depending on how the chickens are fed and their age and size.

Other conditions that affect litter's quality include the age and type of the bedding material, excessive moisture, frequency of cleanouts, and subsequent storage conditions. The constituents of the litter can be estimated from prior analyses of similar wastes, but all litter should be analyzed at least once a year until its nutrient value is firmly established (after that, it may be tested less frequently, perhaps every two or three years unless management practices change).

The volume of litter varies widely, depending on the producer's management style. Indeed, many of the same conditions that determine the litter's makeup also affect its quantity. For example, the feedstock, number of cleanouts, climatic conditions, and bird genetics are all factors. Broilers, however, produce as much as two pounds of litter per bird or about one ton per year per 1,000 birds: about 81 cubic feet of litter for each 1,000 birds.

In 1996, nearly 15.2 billion pounds of litter were produced by broiler operations in the United States — enough to cover 1,619 miles of a two-lane highway to a depth of three feet. This estimate is from the USDA National Agricultural Statistics Service, and the "litter highway" can be imagined as the distance from New Orleans, Louisiana, to Chicago, Illinois, and on to Fargo, North Dakota (Fig. 1).

That much litter can and must be responsibly used. Bedding materials, manure, and used erals in broiler litter include calcium, magnesium, sulfur, sodium, iron, manganese, zinc, and copper.

Table 1.—	
LITTER PRODUCED PER 1,000 BIRDS	
2 lb bird	0.45 ton per cycle
4 lb bird	1.0 ton per cycle
6 lb bird	1.5 ton per cycle
AVERAGE NUTRIENT CONTENT OF BROILER LITTER	
nitrogen	60 lb per ton
P_2O_5	55 lb per ton
K_2O	45 lb per ton

Management Practices

Litter should be kept from becoming overly wet. In a well-managed house, the moisture level in litter will range from 25 to 35 percent. Higher moisture levels increase its weight and reduce its nitrogen value. Litter that does not become saturated can be left in the house between flocks. However, cake (litter that is saturated with water) must be removed from the house between cleanouts to protect the remaining litter. After its removal, the cake should be dried to prevent odor, precautions should be taken to prevent groundwater contamination, and stormwater should be diverted from contact with the litter.

If cake is properly removed from the house, total cleanouts can be delayed — sometimes for an entire year. Checking for water leaks in the house and keeping the house at an even temperature are management practices that reduce the production of cake. The total weight and volume of litter will depend on the type of bedding material used, its depth, whether cake is present or removed, and the length of time between cleanouts. Its quality also depends on how it is removed from the house, whether the floor is raked or stirred between flocks, and how it is stored.

Manure is dried by aerating it using some form of ventilation. Ventilation can be achieved naturally (through proper housing design) or mechanically (through equipment). Aeration should produce a low odor product with about 15 to 25 percent moisture. Because it has less odor and weight, it is less expensive to haul, contains more nutrients, and is easier to store.

Dry Waste Storage Facilities

Common procedures for managing dry broiler litter or dry manure from layer operations center on protecting this material after it is removed from the house until its valuable fertilizer nutrients can be put to other uses. Litter that is not properly stockpiled or stored suffers a reduction of nitrogen from releases to air and water. These losses represent both lost income and the potential for surface and groundwater contamination. To prevent such losses, facilities used for storing dry poultry waste should meet or exceed the following conditions:

- a sufficient capacity to hold the waste until it can be applied to land or transported off the farm,
- adequate conditions of temperature and humidity to permit storage of the waste until it is needed,
- a concrete or impermeable clay base to prevent leaching to groundwater,
- appropriate roofing, flooring, and drainage to present rainfall, stormwater, runoff, and surface or groundwater from entering the waste,
- a location that prevents runoff to surface waters or percolation to groundwater, and
- ventilation and containment for effective air quality and nuisance control.

The ideal storage design is a roofed structure with an impermeable earthen or concrete floor. This design keeps the litter dry, uniform in quality, and easy to handle, and it also minimizes fly and odor problems. Management plans that allow for proper storage achieve the following:

- save water,
- improve bird quality,
- improve the production environment,
- reduce the amount of ammonia released from litter,
- reduce the volume of cake,

- extend the time between cleanouts,
- increase the product's value and flexibility, and
- protect the quality of adjoining waters.

Kinds of Storage Facilities

Generally, storage facilities can be open, covered, or lined (permanently lined, in some cases); or they can be bunkers or open-sided buildings with roofs. Perhaps the most common facilities for collecting and storing poultry litter include floors, pits, dry-stack buildings, or covered outdoor storage facilities with impermeable earthen or concrete flooring.

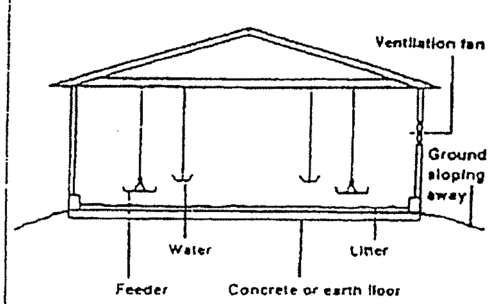
Floor Storage

Most broiler, roaster, Cornish hen, pullet, turkey, and small layer operations raise birds on earthen or concrete floors covered with bedding material (Fig. 1). A layer of wood shavings, sawdust, chopped straw, peanut or rice hulls, or other suitable bedding material is used as a base before birds are housed. Wet litter — that is, cake — is removed after each flock. A complete clean-out can be done after each flock or once every 12 months or longer, depending on the producer's requirements. Slat or wire floor housing, used mainly for breeder flocks, can be handled the same way. Floor storage is the most economical method to store litter. Care must be taken not to leave foreign material such as wire, string, light bulbs, plastic, or screws in the litter.

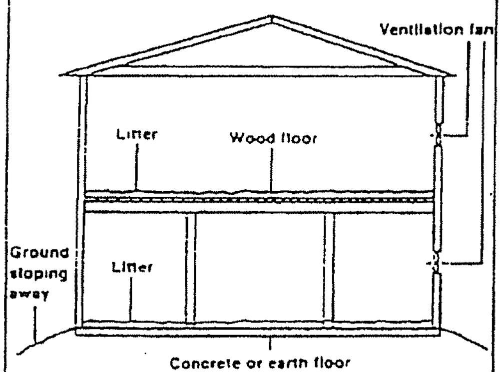
Dry Stack Storage

Temporary storage of litter in a roofed structure with a compacted earthen or concrete floor is an ideal management method (Fig. 2). Large quantities of waste can be stored and kept dry for long periods of time. To prevent excessive heating or spontaneous combustion of wastes, stacks should not exceed 5 to 8 feet and large variations in moisture content should be avoided. Dry stacks promote ease of handling and uniformity of material; in addition, disposal is relatively easy. Dry stacks protect the resource from bad weather and make it available for distribution at appropriate times.

A variation on this option is a stack or windrow located in an open, well-drained area and protected from stormwater runoff. The stack must be covered with a well-secured tarpaulin or other synthetic sheeting.



Single-story poultry house



Two-story poultry house

Figure 1.—Two types of litter-floor poultry houses.

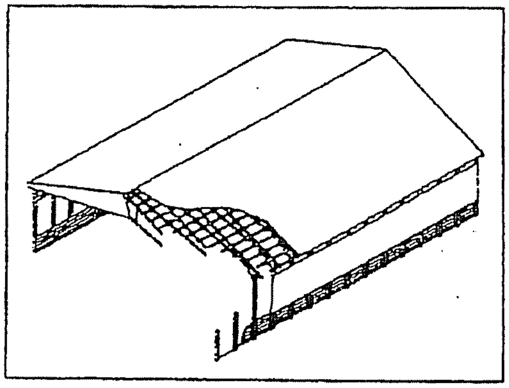


Figure 2.—An ideal dry stack storage facility is a roofed structure with an earthen or concrete floor.

Storage in covered or uncovered facilities is not the only alternative. Field storage on the farm, applicator storage (that is, storage by the crop farmer who will use the litter or manure for fertilizer), cooperative storage (several growers sharing a larger facility off-site), and private storage (by entrepreneurs who will sell or process the litter to create new products) are additional methods of waste storage. Each method must be evaluated in terms of cost, environmental safety, and industry and regulatory practice.

In some states, permits may be required for a storage facility or for other parts of your resource management system. Possible zoning restrictions may also influence your choice of storage systems.

Proper storage is essential to optimize the waste's fertilizer value for crops, provide ease of handling, and avoid groundwater or surface water contamination. Consider also the feasibility of processing alternatives. Waste can be

- composted and pelletized to produce soil amendment and fertilizer products,
- converted to feed for beef cattle or to briquettes for fuel, or
- deposited in lagoons for anaerobic digestion and methane production.

Above all, use soil and manure testing to improve the success (crop yields) and timing of land applications. Practice biosecurity (that is, safeguard the application from disease causing organisms and fly larvae) at all times.

Using poultry litter as a feed supplement for cattle has become popular. Methods of waste handling and storage can greatly affect the quality of the material as a feed ingredient. Litter with the highest nutritional value for refeeding is found in the upper layers of the litter pack. Large amounts of soil increase the ash content and reduce the nutritive value of litter. Feed litter should be deep stacked at least three weeks to ensure that sufficient heat is generated to kill pathogens.

Remember: The use of manure storage structures is a best management practice for the protection of environmental quality, and an interim step in waste management planning. It should be followed by nutrient management planning and appropriate use of the litter for land application.

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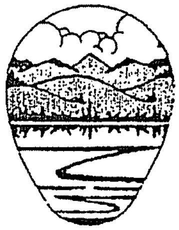

Liquid Waste Management

Ducks, geese, and some layer operations are usually handled through liquid waste management systems, though water greatly increases the amount of waste to be processed. In liquid waste management systems, collection and storage are generally combined in one operation, and in facilities that include pits, settling tanks, and earthen storage ponds, or lagoons. Sometimes additional treatment is used to convert its nutrient and mineral content to more stable products.

Volume comparisons between liquid and dry manure show that 10,000 caged layers produce nearly 2,500 pounds of manure per day, with an estimated volume of 50 cubic feet. In dry form, this manure weighs about 695 pounds, with 10 percent moisture, and reaches a volume of 27 cubic feet. This difference not withstanding, liquid waste management systems can be easier to automate and less labor intensive than dry waste management.

Constraints on the management system appear to be greater when the system is liquid:

- ▼ the pond or other holding facility must be emptied immediately when it is filled — the grower has less flexibility for scheduling land applications;
- ▼ if the waste storage structure is not properly designed and sealed, its contents may leach to groundwater or overflow into ditches, agricultural drains, or other surface water resources;
- ▼ toxic gases or unpleasant odors can occur in liquid waste, particularly when it is agitated or stirred;
- ▼ flies may find the manure storage ponds attractive breeding grounds, especially if they are improperly managed; and — a more important consideration —
- ▼ nearly all states have clean water laws that prohibit wastewater discharges to surface waters and groundwater recharge areas. Therefore, nearly all animal operations that have a liquid waste management system must have formal or informal permits to comply with these laws, even if they are not required to file for federal National Pollution Elimination Discharge System permits.

By contrast, solid waste systems are perceived to have less environmental risks; and with less volume to control, they may also have lower equipment and energy costs. These considerations — and operator preference — may help growers decide between dry and liquid waste management systems.

Lagoon flush systems were a source of environmental and public relations problems (e.g., spills and odors) during heavy rains in 1995 and 1996. If such problems persist, growers and researchers are likely to combine the best features of liquid and dry systems to find more protective and efficient methods of waste management. Researchers in Georgia have already modified a flush-type system beneath a caged layer line to accommodate a deep litter composting system. Plywood boxes containing plywood shavings are placed under the cages to collect the manure, which is turned twice weekly to promote composting.

Liquid Collection Methods — Pit Storage

Layers or pullets are often raised in cages arranged in two to four decks. The manure falls directly into a pit or is scraped into the pit from intervening dropping boards. Pits must be cleaned regularly, and the manure stored in concrete or steel storage tanks or applied directly to the land. A lagoon may be necessary to catch overflow. Ventilation fans are essential to keep the manure dry, and reduce toxic gases, fly problems, and offensive odors.

There are three basic pit designs:

▼ **Shallow-pit systems,** built of concrete at ground level, are 4 to 8 inches deep and located 3 to 6 feet below the cages. Manure is scraped from the pit or flushed out with water and collected in a storage area or loaded directly into a spreader (Fig. 1).

▼ **Deep-pit systems** are usually 4 to 8 feet wide and may extend 2 to 6 feet below ground level with the cages at least 8 feet above the concrete. or masonry floor. The pit floor and sidewalls must be sealed and thoroughly protected from stormwater runoff and groundwater seepage. Foundation drains and external grading are needed to remove subsurface water and to drain surface water away from the building.

▼ **High-rise systems** are similar to deep-pit systems but are built entirely aboveground. The cages are 15 to 30 feet above the ground (Fig. 2). The pit floor should be concrete and graded, with foundation drains. The water supply must be controlled if the wastes are retained in place for extended periods. If outside water penetrates the system and breaks out the side board, the manure can develop a serious fly problem or leach nutrients to groundwater.

Settling Tanks

Concrete, concrete block, or steel storage tanks can be used to collect solids and to skim floating material from a layer operation. A floating baffle or other separator can be installed to remove egg shells, feathers, and other debris. The tank should be placed between the layer house and a waste storage pond or lagoon. Normally, a settling tank is 4 feet at the deep end, sloping to ground level. Walls are slotted to allow drainage of the settled waste.

It is recommended that two settling tanks be installed; one can be drained and cleaned while the other remains in operation. The tanks must be properly constructed and sealed to prevent groundwater or surface water pollution. In tanks and storage ponds, unpleasant odors and dangerous gases may be present and may require protective measures.

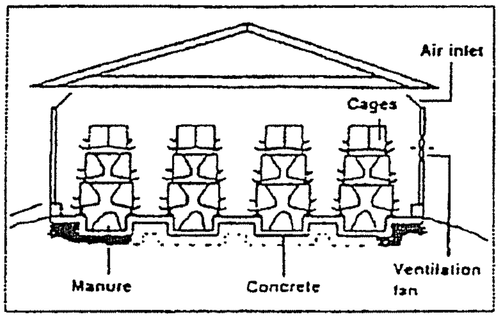

Figure 1.—Shallow-pit poultry house with cages.

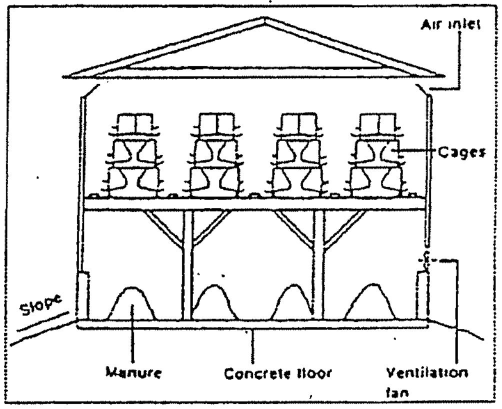

Figure 2.—High-rise poultry house with cages.

Treatment Lagoons and Ponds

Semisolid or liquid manure can be removed from the pits (by flushing or scraping) and stored in below- or aboveground storage tanks, steel storage tanks, or holding ponds. Lagoons, a type of earthen storage basin, have a manure treatment function in addition to a storage function. Lagoons use anaerobic or aerobic bacteria to decompose the waste, and they can even be used as digesters to convert large masses of waste into gases, liquids, or sludge.

Lagoons are easy to manage, convenient, and cost-efficient. Storage and land application can be handled more opportunely if the grower has a lagoon, and labor costs and operating costs are slight after the initial investment. Such facilities became a somewhat popular component of waste management systems during the 1970s when the interest shifted from simply using waste for fertilizer in land applications to treating the waste to produce a more convenient waste management system overall (with less organic content to land apply).

The decomposition process will be anaerobic or aerobic. Anaerobic bacteria in animal waste (i.e., bacteria that live in animal intestines) cannot work in the presence of oxygen. Aerobic bacteria, on the other hand, must have oxygen; therefore, anaerobic lagoons are deep and airless; aerobic lagoons are spread over a large surface area, take in oxygen from the air, and support algae. Both aerobic and anaerobic lagoons provide storage and disposal flexibility.

Other factors, however, must also be considered. Anaerobic lagoons are a source of odors and nitrogen losses and may require frequent sludge removal if they are undersized. Groundwater protection may be difficult to secure in either system. If mechanical aeration is used for an aerobic system, energy costs must be included in the accounting. Proper management is essential for lagoon maintenance and operation.

Aerobic Lagoons

The design, shape, size, capacity, location, and construction of the lagoon depends on its type. Aerobic lagoons require so much surface area (to maintain sufficient dissolved oxygen) that they are an impractical solution to most waste management problems. They may require 25 times more surface area and 10 times more volume than an anaerobic lagoon. Nevertheless, some growers may consider using an aerated lagoon — despite its expense — if they are operating in an area highly sensitive to odor.

Some of the sizing difficulty can be solved by using mechanical aeration — by pumping air into the lagoon — but the energy costs for continuous aeration can be high. Aerobic lagoons will have better odor control, and the bacterial digestion they provide will be more complete than the digestion in anaerobic lagoons.

Lagoon design and loading specifications should be carefully followed and monitored to increase the effectiveness of the treatment. No more than 44 pounds of biological oxygen demand (BOD) should be added to the lagoon per day per acre. The lagoon should have sufficient depth so that light will penetrate the 3 or 4 feet of water. Effluents from the lagoon should be land applied to avoid long-term ponding and to make economical use of the nutrients that remain in them.

Anaerobic Lagoons

Anaerobic treatment lagoons are earthen basins or ponds containing diluted manure that will be broken down or decomposed without free oxygen. In the process, the organic components or BOD in the manure will be liquified or degraded naturally.

Anaerobic lagoons must be properly designed, sized, and managed to be an acceptable animal waste treatment facility.

Liquid volume rather than area determines the size of anaerobic lagoons. The lagoon should accommodate the design treatment liquid capacity and the amount of wastewater to be treated; it should also have additional storage room for sludge buildup, temporary storage room for rain and wastewater inputs, extra surface storage for a 25-year, 24-hour storm event, and at least an additional foot of freeboard to prevent overflows.

The design criteria for anaerobic lagoons are based on the amount of volatile solids to be loaded each day. The range is from 2.8 to 7.0 pounds of volatile solids per day per 1,000 cubic feet of lagoon liquid. The amount of rain that would collect in a 24-hour storm so intense that its probability of happening is once in 25 years requires at least 5 to 9 inches of surface storage, although the actual volume of surface storage required is site specific.

To protect the groundwater supply, lagoons should not be situated on permeable soils that will not seal, on shallow soils, or over fractured rock. The bottom of the lagoon should not be below the water table. Nor should mortalities be disposed of in lagoons. In fact, screening the wastes before they enter the lagoon helps ensure complete digestion and the quality of the wastewaters for land applications. If the site's topography indicates a potential for groundwater contamination, then any earthen basin should be lined with clay, concrete, or a synthetic liner.

New lagoons should be filled one-half full with wastewater before waste loading begins. Planning start up in warm weather and seeding the bottom with sludge from another lagoon helps to establish the bacterial population. Because bacterial activities increase in high temperatures, lagoons, in general, work best in warm climates. Manure should be added to anaerobic lagoons daily, and irrigation (drawdown) should begin when the liquid reaches normal wastewater maximum capacity. The liquid should not be pumped below the design level treatment, however, because the proper volume must be available for optimum bacterial digestion.

Drawdown (that is, the lagoon liquid) can be used for land applications guided by regular nutrient management planning and sampling of the lagoon liquids and soils to ensure safe and effective applications. When sludge accumulation diminishes the lagoon's treatment capacity, it, too, can be land applied under strictly monitored conditions.

Secondary lagoons are often needed for storage from the primary lagoon. Using a secondary lagoon for irrigation also bypasses some of the solids picked up in the primary lagoon. The size of secondary lagoons is not critical.

Information and technical assistance and some cost-share programs are available for producers who determine that a lagoon system should be part of their resource management system. The USDA Natural Resources Conservation Service (NRCS) and the Cooperative State Research, Extension, and Education Service offices can provide additional assistance.

Land Applications

Land application of liquid waste can be achieved with a manure slurry or irrigation system. If the application falls directly on the crop, care must be taken to prevent ammonium toxicity and burning. Because raw manure contains high amounts of uric acid, it should be thoroughly mixed before application. Layer lagoon sludge is more dense than a pullet lagoon sludge because of its high grit or limestone content and should be diluted before application.

Timing is a major factor in successful land applications. There should be no land application prior to, during, or immediately following a rainfall event. The manure must also be uniformly applied — whether you are using a manure spreader or an irrigation system. The operator should be particularly careful (especially during a drought) not to coat the plants with lagoon liquid. Instead, make several small applications of lagoon liquid, rather than one large one.

Liquid waste is primarily disposed of through land applications. Proper spreading on the land is an environmentally acceptable method of managing waste. However, with increasing environmental concerns and the need to match closely the fertilizer needs of crops, farmers can no longer afford to simply "spread manure."

The USDA NRCS, Cooperative State Research, Extension and Education Service, and other agencies offer poultry waste and nutrient management planning assistance. These offices have worksheets to help growers plan liquid waste management, which includes the following tasks:

- determining the amount and volume of waste generated;
- calculating land application requirements;
- sampling and analyzing the nutrient composition in poultry litter, manure, or slurry; and
- matching the nutrients available in these products with crop nutrient requirements for land applications.

Detailed information on how to prepare nutrient assessments, conduct soil testing, and calculate application rates, timing, and methods of application are also available from these agencies.

The use of nutrient management planning will help growers make economical and practical use of the organic resources generated on their farms.

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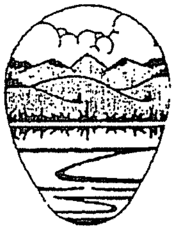

Composting Waste Products

Poultry litter or layer manure is most often land applied to pastures and crops for its value as an organic fertilizer. We know from long experience how beneficial this practice can be when soil and manure nutrient testing are integrated with crop nutrient needs to determine the amount and timing of the application. This integration makes it possible to approach land application as a wise use of resources rather than as a disposal method.

Proper storage and treatment of poultry by-products (litter, manure, hatchery waste, and dissolved air flotation [DAF] skimmings) before use are important to minimize compositional changes and decrease odor and handling problems. Depending on the by-product, dry storage, ensiling, or composting may be appropriate treatments. Resource management systems may include incineration and burial as methods of disposal; however, these techniques are not called treatments because they do not usually provide any reusable products.

Composting is an environmentally sound and productive way to treat poultry by-products and mortalities (see also PMM/4 and PMM/5). The product of composting is easier to handle, has a smaller volume, and is a more stable product than the raw materials. The nutrient content of the compost will be nearly the same as the starting materials if the composting is performed properly.

While compost can be land applied to decrease the need for nutrients from commercial fertilizers, composted by-products may also be marketed for higher value uses on turf, for horticultural plant production, and in home gardening landscaping. It can be added as an amendment to soils for transplanting flowers, trees, and shrubs, or to establish new lawns. Compared to commercial fertilizers, poultry by-product compost will have a lower nutrient analysis (e.g., 2-2-2) for nitrogen, phosphorus, and potassium. However, there are other benefits to the soil and plant growth associated with the organic matter and micronutrients in compost.

Understanding the Process and Benefits of Composting

Composting is a natural, aerobic, microbiological process in which carbon dioxide, water, and heat are released from organic wastes to produce a stable material. Leaves and other organic debris are subject to this process all the time — that is, the activity of microorganisms transforms these materials into a soil-like, humus-rich product.

This natural process can also be used as a resource management technique to transform large quantities of litter, manure, and other poultry by-products into compost. The conditions under which natural composting occurs can be stimulated and controlled so that the materials compost faster and the nutrient value of the compost is maximized.

The composting process is relatively simple:

1. By-products, for example, litter, manure, eggshells, hatchery waste, and DAF skimmings, are placed in bins, piles, or elongated piles called windrows. A bulking agent or carbon amendment (e.g., sawdust, wood chips, yard waste, or paper that is rich in carbon but low in other nutrients) is usually necessary to provide the proper ratio of carbon to nitrogen in the mix and to improve aeration.

2. Air is needed to support and enhance microbial activity. Because the composting microorganisms are aerobic, that is, oxygen using, the windrows and compost piles must be aerated to ensure the